US009838768B2

(12) United States Patent
Matsui et al.

(10) Patent No.: US 9,838,768 B2
(45) Date of Patent: Dec. 5, 2017

(54) **MICROPHONE DEVICE**

(71) Applicants: **Noriko Matsui**, Tokyo (JP); **Hiroshi Akino**, Tokyo (JP)

(72) Inventors: **Noriko Matsui**, Tokyo (JP); **Hiroshi Akino**, Tokyo (JP)

(73) Assignee: **KABUSHIKI KAISHA AUDIO TECHNICA**, Tokyo (JP)

(21) Appl. No.: **14/867,603**

(22) Filed: **Sep. 28, 2015**

(65) **Prior Publication Data**

US 2016/0119702 A1 Apr. 28, 2016

(30) **Foreign Application Priority Data**

Oct. 27, 2014 (JP) 2014-218171

(51) **Int. Cl.**

H04R 21/02	(2006.01)
H04R 1/08	(2006.01)
H04R 1/04	(2006.01)
H04R 1/06	(2006.01)
H04R 19/04	(2006.01)

(52) **U.S. Cl.**

CPC ***H04R 1/083*** (2013.01); *H04R 1/04* (2013.01); *H04R 1/06* (2013.01); *H04R 19/04* (2013.01); *H04R 2410/03* (2013.01)

(58) **Field of Classification Search**

CPC H04R 3/007; H04R 2410/03; H01B 11/1066; H01B 11/06; H01B 11/1058

USPC 381/363

See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

4,426,636	A *	1/1984	Ohta	H01B 1/24 29/613
5,208,426	A *	5/1993	Kennedy	H01B 11/1066 174/102 SC
5,548,082	A *	8/1996	Palmer	H01B 11/1091 174/34
7,526,097	B2 *	4/2009	Akino	H04R 1/08 381/189
8,150,088	B2 *	4/2012	Akino	H04R 1/04 381/189
8,488,830	B2 *	7/2013	Yoshino	H04R 1/086 381/189
8,520,879	B2 *	8/2013	Yoshino	H04R 1/086 381/361
8,735,725	B2 *	5/2014	Li	H01B 1/24 174/107
2011/0048764	A1 *	3/2011	Hira	H01B 11/10 174/105 R

FOREIGN PATENT DOCUMENTS

FR	2983626	A1 *	6/2013	H01B 11/1066
JP	2006-33216	A	2/2006	

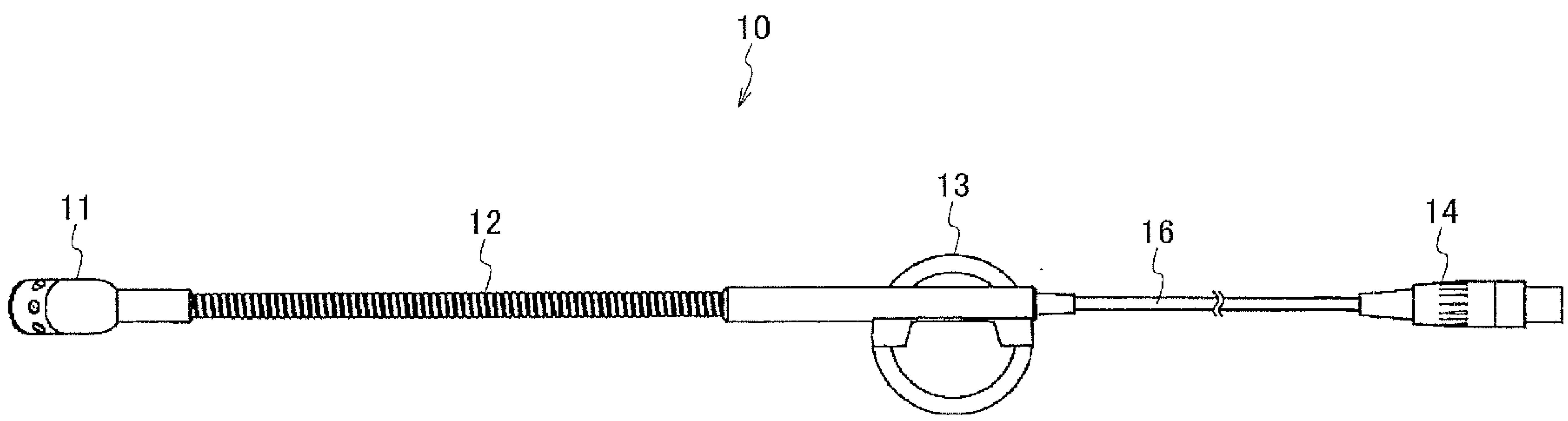
* cited by examiner

Primary Examiner — Curtis Kuntz
Assistant Examiner — Ryan Robinson
(74) *Attorney, Agent, or Firm* — Whitham, Curtis, & Cook

(57) **ABSTRACT**

The microphone device includes a tubular support of a conductive material. A microphone unit is provided at one end of the support and grounded to the support. A cable passes through the support and includes core wires connected to a signal output terminal of the microphone unit. A conductive covering material that covers the core wires and is electrically connected to the support.

8 Claims, 12 Drawing Sheets



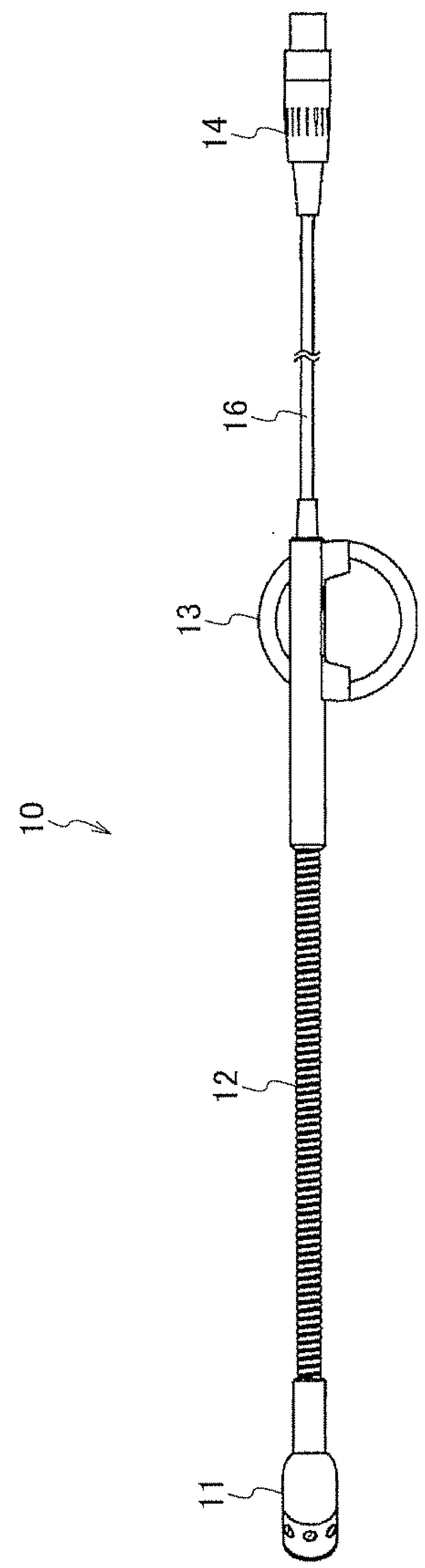


FIG.1

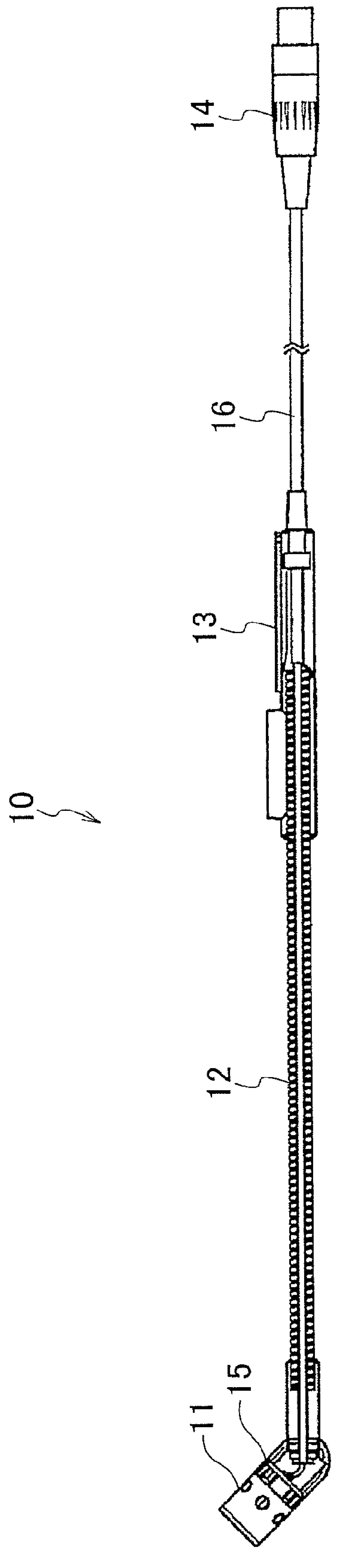


FIG.2

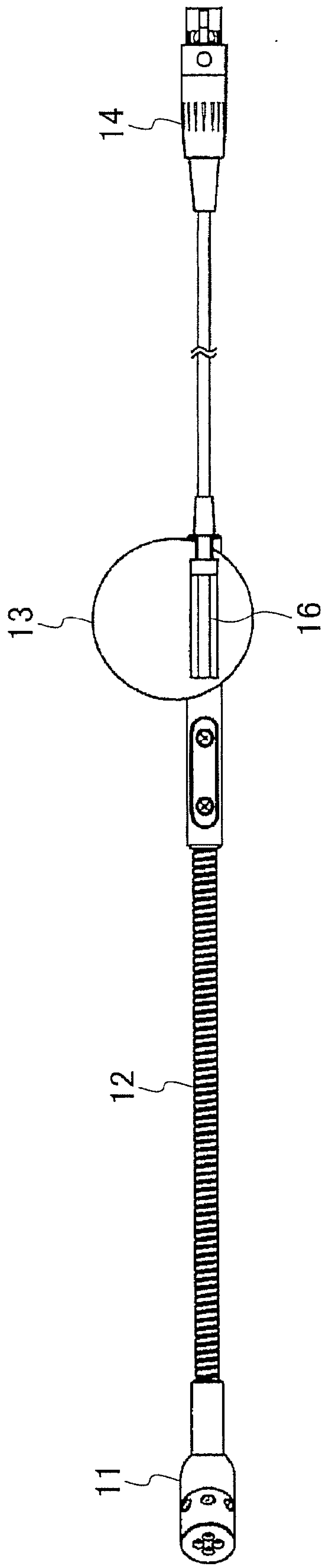


FIG.3

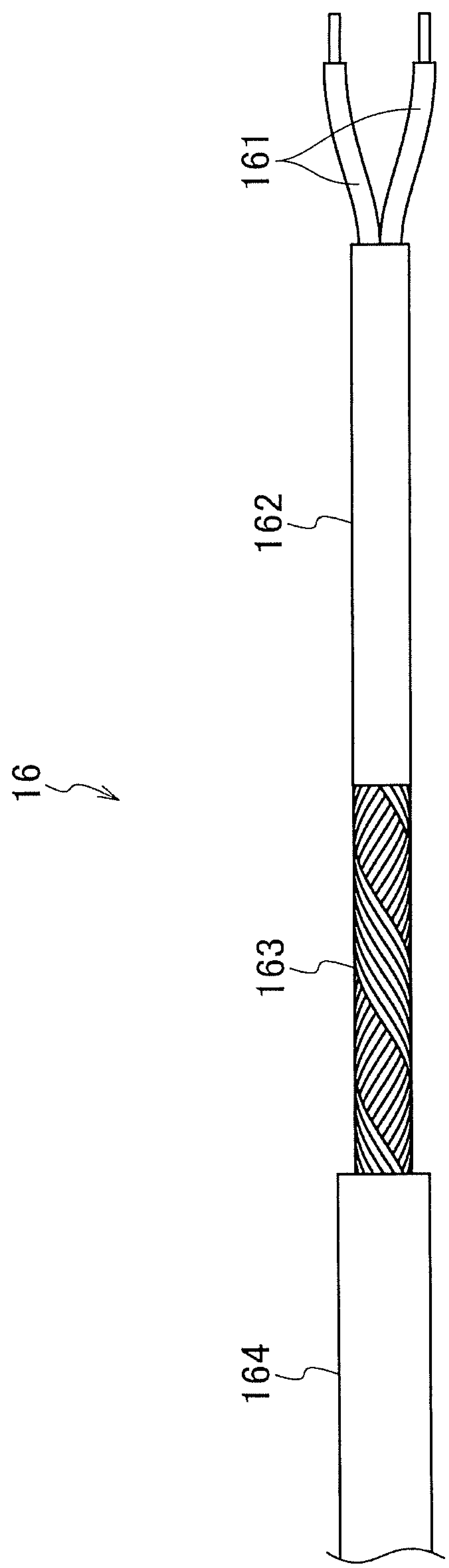


FIG.4

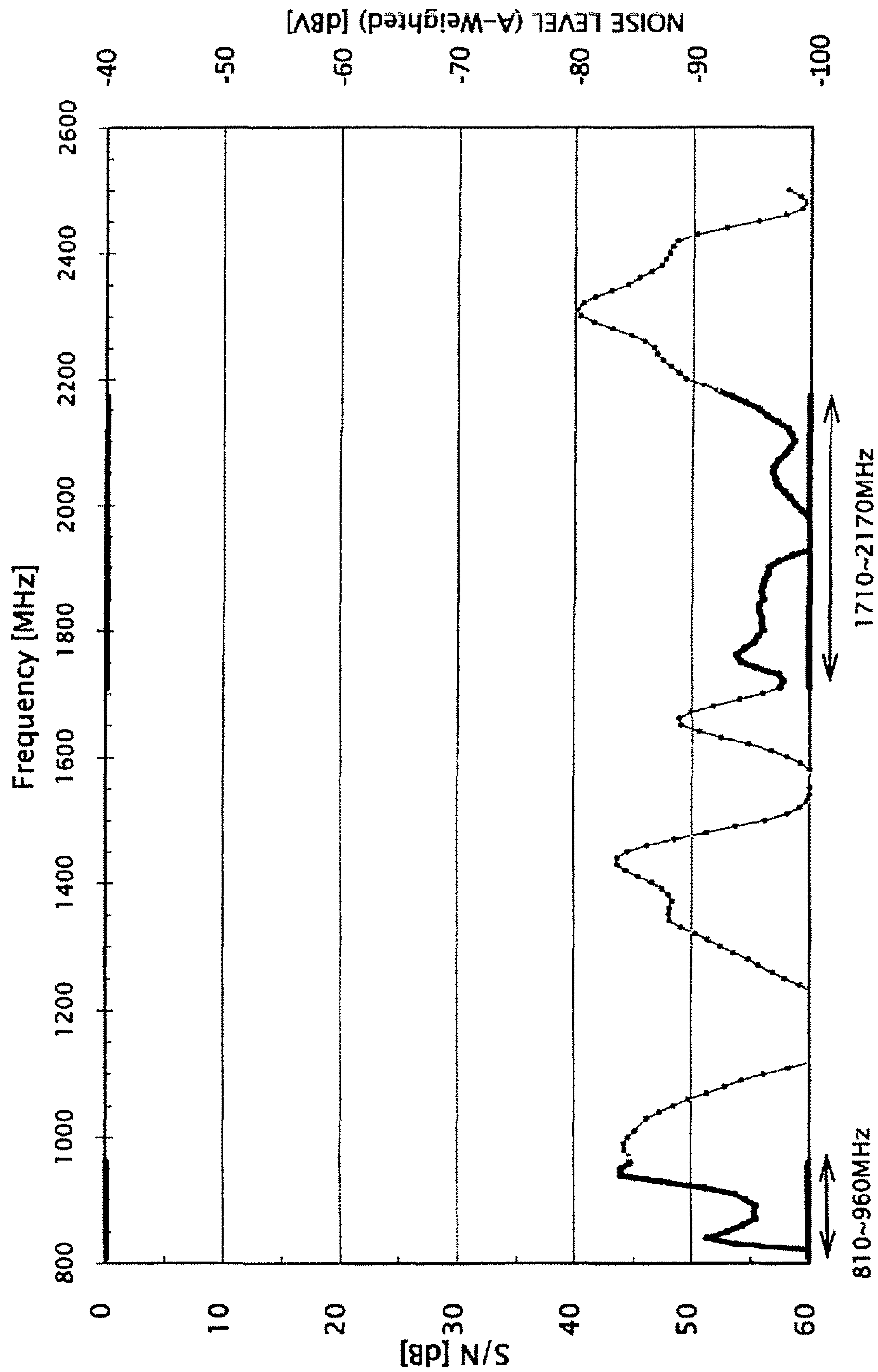

NOISE LEVEL (A-Weighted) [dBV]
-40
-50
-60
-70
-80
-90
-100
Frequency [MHz]
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
S/N [dB]
0
10
20
30
40
50
60
810~960MHz
1710~2170MHz

FIG.5

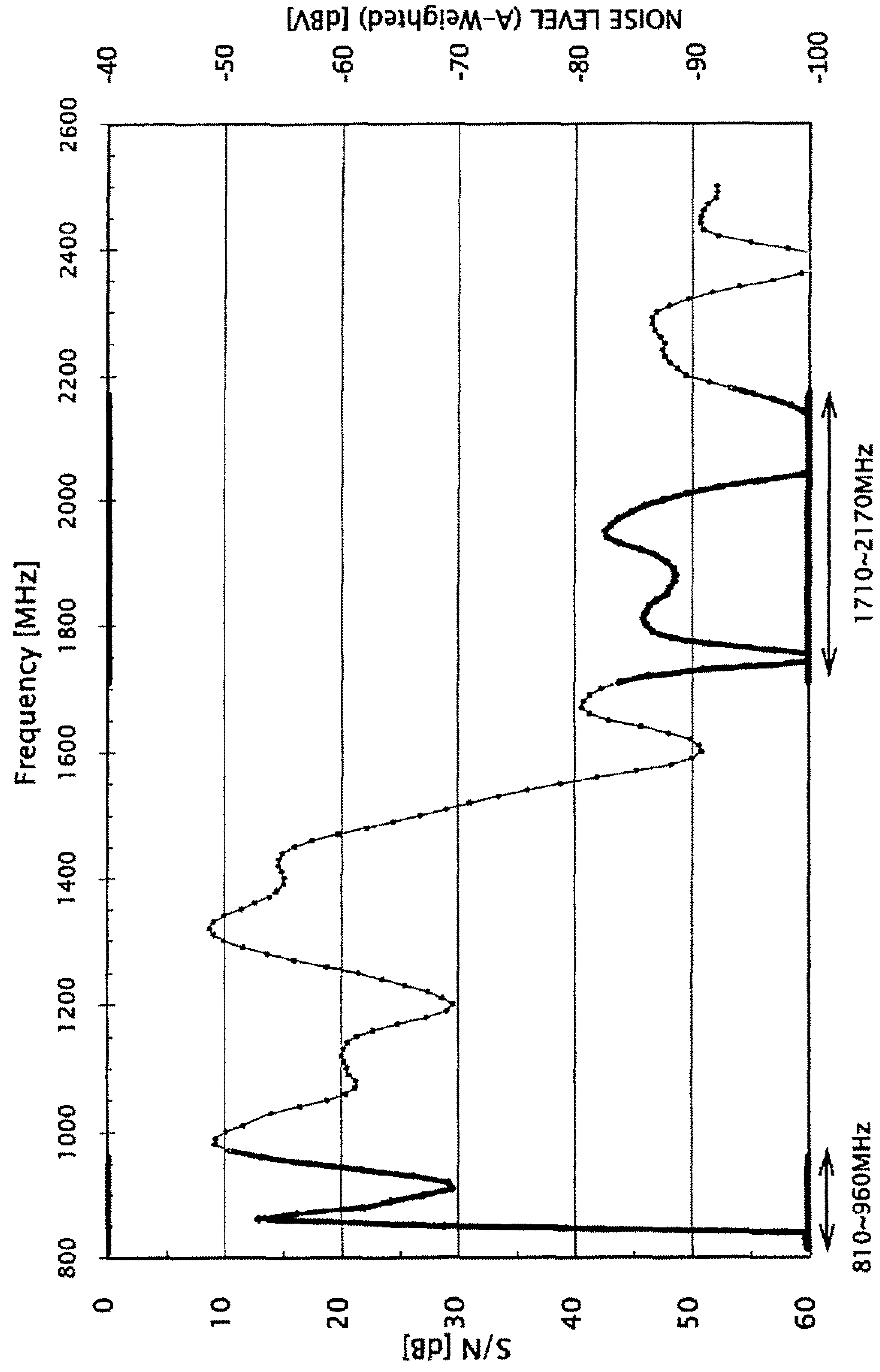


FIG.6
(Related Art)

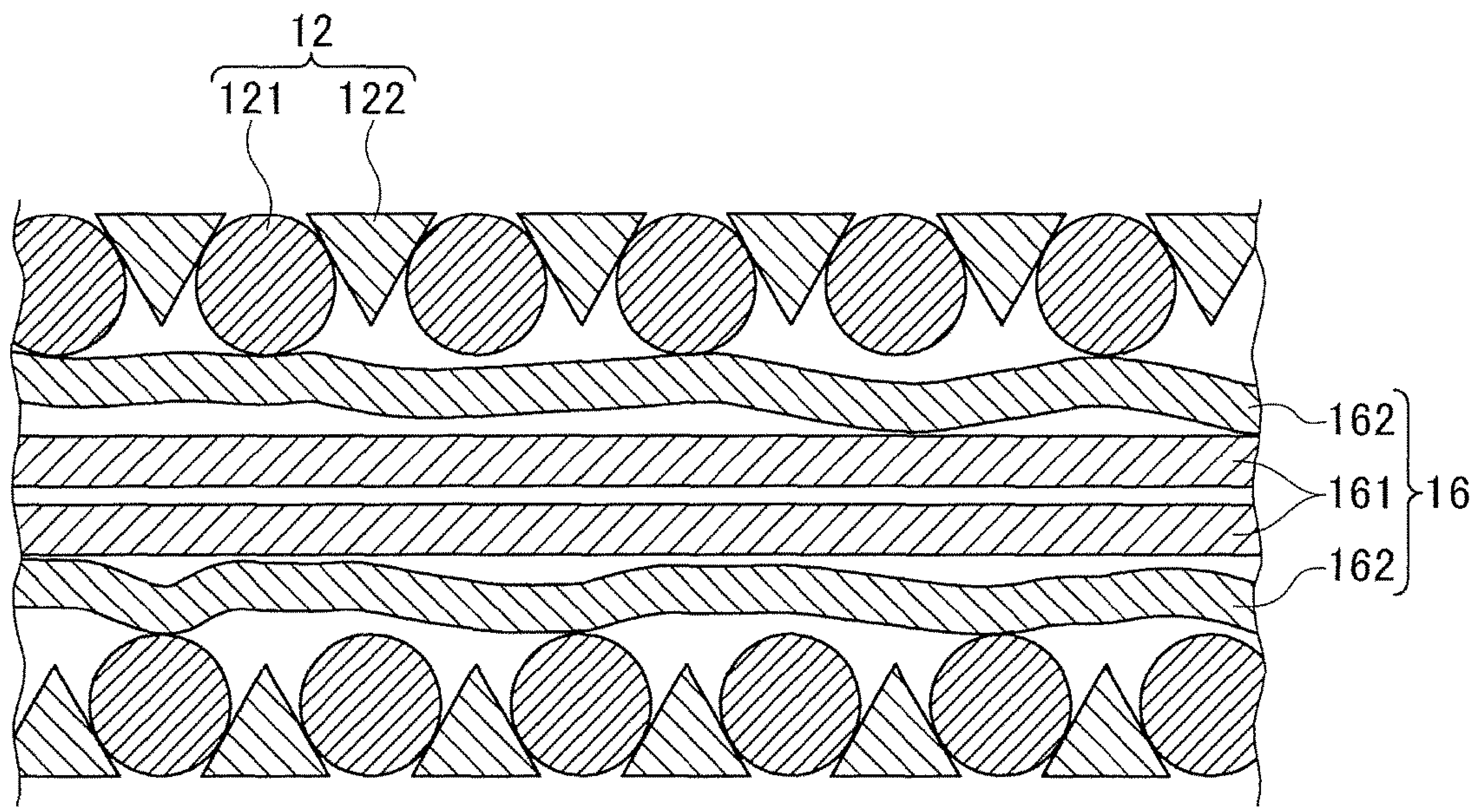


FIG.7

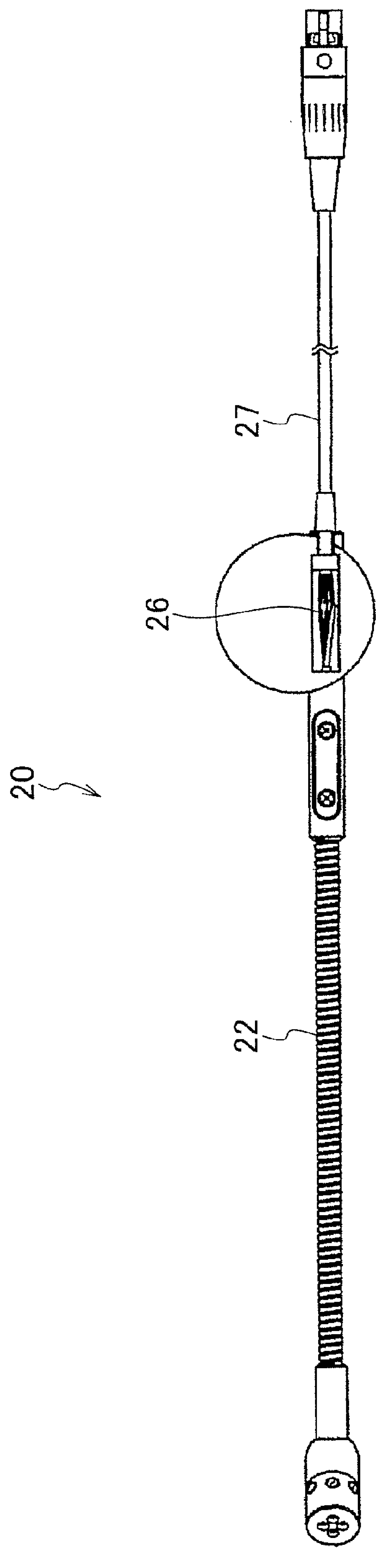


FIG.8
(Related Art)

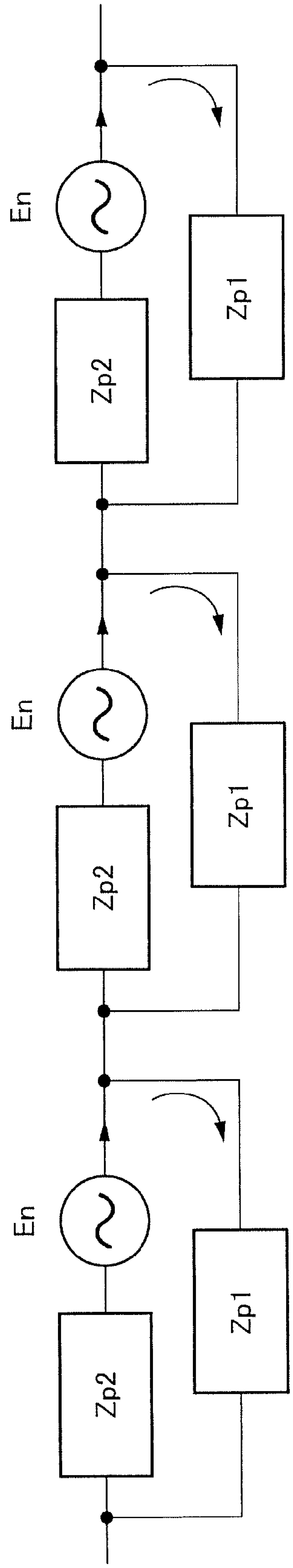


FIG.9

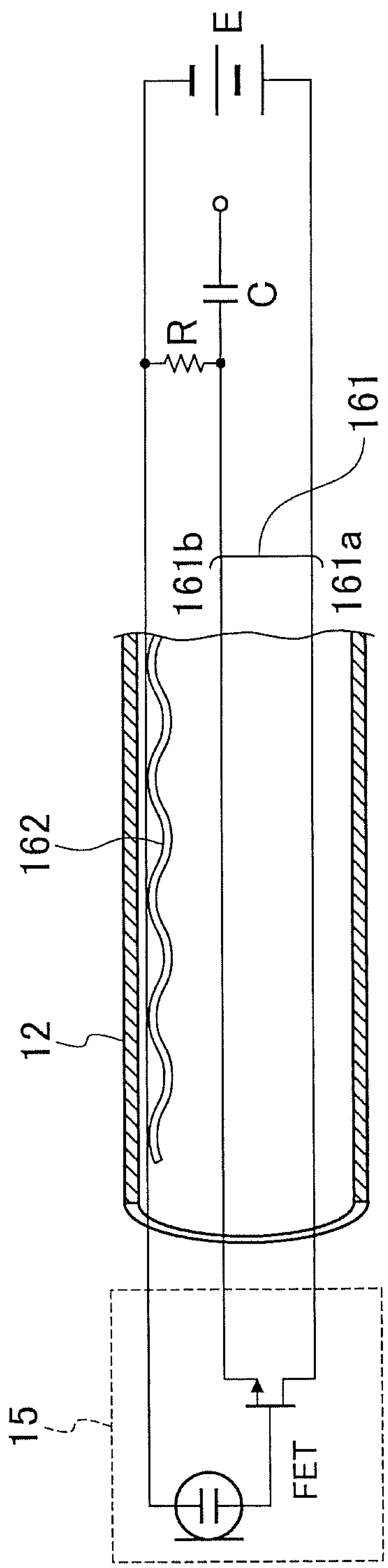


FIG.10

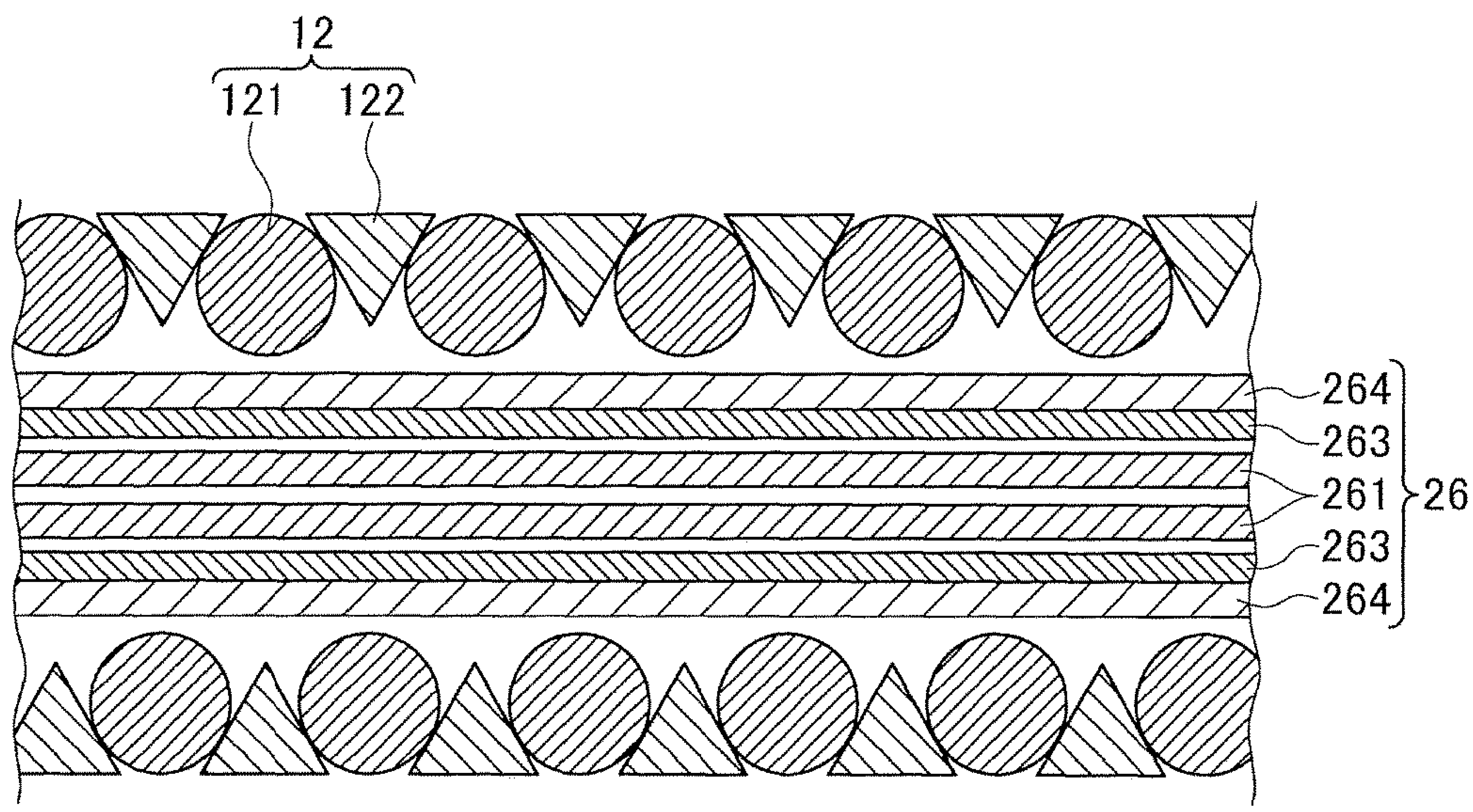


FIG.11
(Related Art)

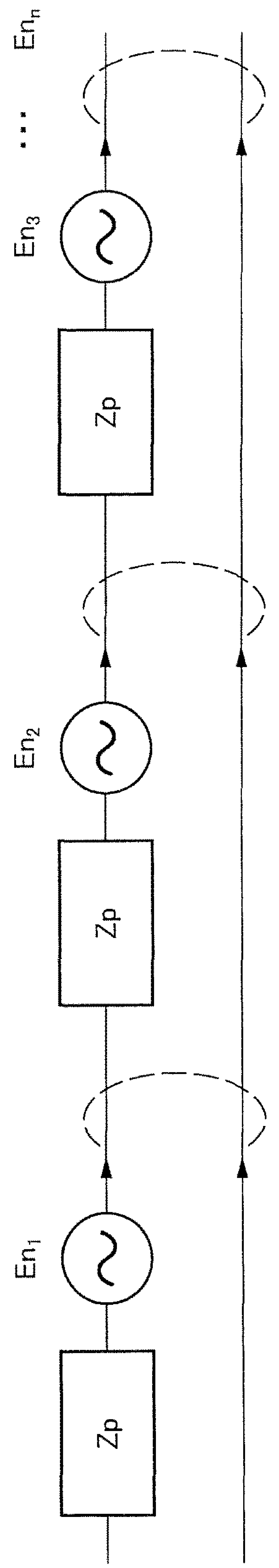


FIG.12
(Related Art)

MICROPHONE DEVICE

TECHNICAL FIELD

The present invention relates to a microphone device.

BACKGROUND ART

A typical microphone device is known which has a microphone unit distanced from the base, specifically, has a microphone unit at the tip of the rod support on the base. Examples of such a microphone device include headset microphones and goose-neck microphones.

A headset microphone has a flexible support pipe with a cable passing therethrough for electrical connection to the microphone unit. The flexible pipe in the headset microphone is made thin (has a small inner diameter) not to draw much attention. A thick cable, which is difficult to pass through the flexible pipe, is connected to the thin cable at or around the inlet of the flexible pipe.

Condenser microphones, which are typically used as microphone units in headset microphones, suffer from audible noise caused by RF current flowing through impedance converters in the condenser microphones. To prevent such noise, the audio signal wires in the microphone are protected (shielded) from static damage. Unfortunately, the junction between the thick and thin cables at or around the inlet of the flexible pipe cannot be adequately shielded.

For example, Japanese Unexamined Patent Application Publication No. 2006-033216 (hereinafter referred to as "the patent literature") discloses a condenser microphone in which the inner surface of a metal pipe is in contact with an exposed shield-covered cable in the pipe for the microphone. The shield-covered cable in the technique in the patent literature is a braided cable consisting of core wires and a copper braid therearound.

Even in the technique in the patent literature, a cable cannot be passed through a pipe with a small inner diameter and adequate shielding is not achieved due to a gap between the inner wall of the pipe and the low-density shielded wire.

SUMMARY OF INVENTION

Technical Problem

An object of the present invention is to provide a microphone device with improved shielding in and around the support.

Solution to Problem

The present invention includes a tubular support of a conductive material, a microphone unit that has a signal output terminal and is provided at and grounded to one end of the support, and a cable passing through the support. The cable includes core wires connected to the signal output terminal of the microphone unit, and a conductive coat that covers the core wires and is electrically connected to the support.

Advantageous Effects of Invention

The present invention improves shielding in and around the support.

BRIEF DESCRIPTION OF DRAWINGS

FIG. **1** is a side view illustrating an embodiment of a microphone device of the present invention.

FIG. **2** is a partial cross-sectional view of the microphone device in FIG. **1**.

FIG. **3** is a partial cross-sectional view of the microphone device in FIG. **1**.

FIG. **4** is a schematic view of a cable in the microphone device in FIG. **1**.

FIG. **5** is a graph showing the noise spectrum of the cable in FIG. **4**.

FIG. **6** is a graph showing the noise spectrum of a cable of the related art.

FIG. **7** is a partial enlarged cross-sectional view of the cable in the support of the microphone device in FIG. **1**.

FIG. **8** is a partial cross-sectional view of a microphone device of the related art.

FIG. **9** is the equivalent circuit diagram of the support and the cable of the microphone device in FIG. **1**.

FIG. **10** is a diagram of an example audio signal circuit in the microphone device in FIG. **1**.

FIG. **11** is a partial enlarged cross-sectional view of a cable in a support of a microphone device of the related art.

FIG. **12** is an equivalent circuit diagram of a support and a cable of a microphone device of the related art.

DESCRIPTION OF EMBODIMENTS

Now will be described an embodiment of a microphone device of the present invention with reference to the attached drawings.

As shown in FIG. **1**, a microphone device **10** of this embodiment is a headset microphone which is mounted on the speaker's head. The microphone device **10** includes a microphone case **11** accommodating a microphone unit **15** to be described below and a flexible pipe **12** supporting the microphone case **11**. The microphone device **10** further includes a pad **13** to be in contact with the speaker's head and a connector **14** to connect the microphone device **10** to an external apparatus.

Referring to FIGS. **2** and **3**, the microphone case **11** is a substantially cylindrical case provided at one end of the flexible pipe **12**. The microphone case **11** can accommodate the microphone unit **15**. The microphone case **11** has openings to admit external voice.

The microphone unit **15** includes a diaphragm, a back plate, and a circuit to operate the microphone device. The microphone unit **15** is generally a compact lightweight condenser microphone. The condenser microphone includes an impedance converter. A capacitor in the condenser microphone, which is composed of the diaphragm and the back plate, has a low capacitance. The condenser microphone thus includes, for example, a field effect transistor (FET) with high input impedance as the impedance converter. The microphone unit **15** is grounded to the flexible pipe **12**.

The flexible pipe **12**, one example of the support, has the microphone case **11** at one end and the pad **13** at the other end. A typical headset microphone or goose-neck microphone includes the flexible pipe **12** which allows the microphone unit **15** to be moved to and fixed in an appropriate position to the speaker's mouth. The flexible pipe **12** is a hollow cylinder with a cable **16** passing therethrough. The cable **16** has the microphone unit **15** at one end and the connector **14** at the other end and electrically connects these components to each other.

The pad **13** is a base supporting the microphone case **11** and the flexible pipe **12**. The pad **13** includes a hollow-cylindrical segment with the cable **16** passing therethrough and a holding segment to come into contact with the speaker's head to fix the position of the microphone unit **15**.

Structures of Cable and Flexible Pipe

The structures of the cable **16** and the flexible pipe **12** in the microphone device **10** will now be described.

As shown in FIG. **4**, the cable **16** includes core wires **161** connected to the signal output terminal of the microphone unit **15** and a conductive covering material **162** covering the core wires **161**. The cable **16** further includes a shielding braid **163** covering the conductive covering material **162** and an insulating covering material **164** covering the shielding braid **163**. The conductive covering material **162** directly covers the core wires **161** without a sealant or any other material therebetween. The conductive covering material **162** has an outer surface electrically connected to the inner surface of the flexible pipe **12**.

A typical cable has a capacitor storing electric charge between each core wire and shielding braid. The capacitance of the capacitor varies in response to the stress applied to the cable. The cable **16** thus causes microphonic noise.

To reduce the noise caused by variations in the capacitance in the cable **16** of the microphone device **10**, the cable **16** includes the conductive covering material **162** (conductive tube) that is disposed between the shielding braid **163** and each core wire **161** and is composed of a resin, such as polyvinyl chloride (PVC) containing conductive particles, such as carbon black. The resistivity of the conductive covering material **162** is approximately 10-10^7 Ω·cm.

Comparison between the noise spectrum of the cable **16** in FIG. **5** and that of a cable of the related art in FIG. **6** demonstrates that the noise level of the cable **16** is much lower than that of the cable of the related art over the estimated noise frequency range on the whole.

As shown in FIG. **7**, the flexible pipe **12** is composed of a first wire rod **121** and a second wire rod **122** inserted in the space in the first wire rod **121**. The first wire rod **121** is a coil spring of a steel wire or any other wire with a circular section. The second wire rod **122** is a coil spring of a brass wire or any other wire with a triangular section. The friction between the first wire rod **121** and the second wire rod **122** both made of a flexible plastic conductive material enables the flexible pipe **12** to be deformable while keeping its basic tubular shape. The flexible pipe **12** in the headset microphone is made thin (has a small inner diameter) not to draw much attention.

The shielding braid **163** and the insulating covering material **164** are removed from the cable **16** in the flexible pipe **12**. The shielding braid **163** and the insulating covering material **164** are removed from the cable **16** and the remaining core wires **161** and conductive covering material **162** are passed through the flexible pipe **12**.

The flexible pipe **12** has such an inner diameter that the cable **16** can pass therethrough while the conductive covering material **162** around the core wires **161** is in contact with the inner wall of the flexible pipe **12**. In the flexible pipe **12**, the conductive covering material **162** around the core wires **161** is in continuous or intermittent contact with the inner wall of the flexible pipe **12**.

In a headset microphone, a cable should be thin to pass through a flexible pipe. For this reason, as in the related art in FIG. **8**, a conventional microphone device **20** has a cable **26** in the flexible pipe **22** and a cable **27** outside the flexible pipe **22**, which cables are connected to each other at or around the opening of the flexible pipe **22**. The cable **26** has a smaller outer diameter than the cable **27**. Since the headset microphone includes many resin components, adequate shielding from static damage is not achieved at the junction between the cable **26** in the pipe and the cable **27** out of the pipe.

In the microphone device **10** of this embodiment, as described above, the core wires **161** and the conductive covering material **162** are passed through the flexible pipe **12** and the conductive covering material **162** is electrically connected to the inner wall of the flexible pipe **12**. Thus, in the microphone device **10**, the resistance generated between the flexible pipe **12** and the conductive covering material **162** consumes the electric power from the RF current induced in the flexible pipe **12** by intense RF waves, thereby reducing noise.

In addition, the shielding braid **163** in the microphone device **10** is electrically connected to around the opening of the flexible pipe **12**, improving the shielding of the microphone device **10**.

With reference to FIG. **9**, will be explained how the resistance generated between the flexible pipe **12** and the conductive covering material **162** consumes the electric power from the RF current. In the drawing, the RF current is supposed to be generated from the power supply En. In the microphone device **10**, the conductive covering material **162** and the flexible pipe **12** are electrically connected at multiple points, and every pair of connection points constitutes a loop circuit. In this circuit, the RF current is attenuated by impedance Zp**1** from the resistance of the conductive covering material **162** and impedance Zp**2** from the resistance of the flexible pipe **12**.

FIG. **10** is a diagram of an example audio signal circuit in the microphone device **10**. As shown in the drawing, direct current E is supplied to the microphone unit **15** including an electroacoustic transducer and the impedance converter, through a power supply line **161***a* of the core wires **161**, in the microphone device **10**. An FET constituting the impedance converter has a source connected to a capacitor C through a signal line **161***b*, and a drain connected to one terminal of a power supply E. The ground pattern of a circuit substrate contained in the microphone unit **15** is connected to the conductive covering material **162** and the flexible pipe **12** for connection to the other terminal of the power supply E. Such connection constitutes a part of the audio signal circuit that contains the microphone unit **15**.

In a microphone device of the related art illustrated in FIG. **11**, core wires **261** in a cable, a shielding braid **263** around the core wires **261**, an insulating covering material **264** around the shielding braid **263** are passed through the flexible pipe **22**. As shown in FIG. **12**, such a microphone device of the related art includes a plurality of circuits, each composed of impedance Zp from the resistance of the cable **26** and a power supply En generating RF current, which are sequentially connected in series. Hence, RF current in the microphone device of the related art is not attenuated but accumulated to increase the noise level.

Advantageous Effects of Embodiment

As explained above, the microphone device of this embodiment provides the following advantageous effects.

In the microphone device **10**, the resistance of the conductive covering material **162** attenuates RF current, thereby reducing the noise in the audio signals.

Although a headset microphone requires a mechanically strong cable that is not broken even by the strenuous movement of the speaker, the microphone device of the related art may be subjected to a wire break or intrusion of water at the junction.

In contrast, the microphone device **10** of this embodiment does not include any junction of the cable **16** inside or outside the flexible pipe **12** as described above, improving the mechanical strength and water impermeability of the cable **16**.

The flexible pipe used as a support in the embodiment may be replaced with an inflexible or rigid pipe.

The invention claimed is:

1. A microphone device comprising:

a tubular support of a conductive material wherein the tubular support has a first and a second end;

a microphone unit having a signal output terminal, the microphone unit being disposed at a first end of the tubular support and grounded to the tubular support; and

a cable passing having a first portion through the tubular support to the microphone unit and a second portion extending from the second end of the tubular support, the cable comprising:

core wires connected to the signal output terminal of the microphone unit;

a conductive covering material covering the core wires;

a shielding braid covering the conductive covering material at the second portion of the cable;

an insulation material covering the shielding braid at the second portion of the cable;

wherein the conductive covering material is electrically connected to the tubular support at the first portion of the cable,

wherein the conductive covering material directly covers the core wires without any other material therebetween.

2. The microphone device of claim **1**, wherein the covering material is in intermittent contact with the inner wall of the support.

3. The microphone device of claim **1**, wherein the covering material is in continuous contact with the inner wall of the support.

4. The microphone device of claim **1**, wherein the support is a flexible pipe.

5. The microphone device of claim **1**, wherein the tubular support and the conductive covering material are electrically connected to each other to constitute a circuit configured to consume the electric power from RF current induced in the tubular support.

6. The microphone device of claim **1**, further comprising a base at the other end of the support, the base supporting the microphone unit and the support.

7. The microphone device of claim **1**, wherein the conductive covering material is composed of a resin containing conductive particles.

8. The microphone device of claim **7**, wherein the resin is polyvinyl chloride (PVC) and the conductive particles are carbon black.

* * * * *